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      TORKKELL, Sirke
      PALMU, Kaisa
      HAKALA, Juha

<120> GENE CLUSTER INVOLVED IN NOGALAMYCIN BIOSYNTHESIS,
      AND ITS USE IN PRODUCTION OF HYBRID ANTIBIOTICS

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gcggagccgg cacctggtcg acggccgccg tgtacggggt gccgcaggtc tccctgggct 12960

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tggtcgacgt cccggtggaa cgcggctgca tgaccttcgt ccccggatca cacctgctgc   15960

cggatcccga taccggcgac gagccgtggg ccggggcctt cacccggccg ggagagatct   16020

<210> 2
<211> 342
<212> PRT
<213> Streptomyces nogalater ATCC 27451

<220>
<223> "translate of snogI, function: aminotransferase"

<400> 2

Met Thr Val His Val Trp Asp Tyr Leu Pro Glu Tyr Glu Leu Glu Arg
1   5   10   15

Glu Asp Ile His Asp Ala Val Glu Thr Val Phe Arg Ser Gly Arg Leu
        20   25   30

Val Leu Gly Glu Ser Val Arg Gly Phe Glu Ser Glu Phe Ala Ser Phe
        35   40   45

Gln Gly Val Gly His Ala Val Gly Val Asp Asn Gly Thr Asn Ala Val
        50   55   60

Lys Leu Gly Leu Gln Ala Leu Gly Val Gly Pro Gly Asp Glu Val Val
65   70   75   80

Thr Val Ser Asn Thr Ala Ala Pro Thr Val Val Ala Ile Asp Ser Ala
                85   90   95

Gly Ala Thr Pro Val Phe Val Asp Val Arg Glu Glu Asp Tyr Leu Met
            100   105   110

Asp Thr Ser Gln Val Glu Ala Val Leu Thr Pro Arg Thr Arg Cys Leu
        115   120   125

Leu Pro Val His Leu Tyr Gly Gln Cys Val Asp Met Ala Pro Leu Arg
        130   135   140

Asp Leu Ala Ala Arg His Asn Leu Val Ile Leu Glu Asp Cys Ala Gln

Ala His Gly Ala Arg Arg His Gly Arg Leu Ala Gly Ser Thr Gly Asp
            165   170   175

Ala Ala Ala Phe Ser Phe Tyr Pro Thr Lys Val Leu Gly Ala Tyr Gly
            180   185   190

Asp Gly Gly Ala Val Leu Thr Asp Asp Glu Arg Val Ala Asp Arg Leu
            195   200   205

Arg Arg Leu Arg Tyr Tyr Gly Met Glu Ser Arg Tyr Tyr Val Val Glu
            210   215   220

Thr Pro Gly His Asn Ser Arg Leu Asp Glu Val Gln Ala Glu Ile Leu
225   230   235   240

Arg Arg Lys Leu Ser Arg Leu Pro Ser Tyr Ile Glu Ala Arg Arg Ala
            245   250   255

Val Ala Arg Arg Tyr Glu Glu Gly Leu Ala Asp Thr Gly Leu Leu Leu
            260   265   270

Pro Arg Thr Ala Gln Gly Asn Glu His Val Tyr Tyr Val Tyr Val Val
            275   280   285

Arg His Pro Arg Arg Asp Ala Val Leu Glu Ala Leu Arg Ala Ser Tyr
            290   295   300

Asp Ile Ala Leu Asn Ile Ser Tyr Pro Trp Pro Val His Thr Met Thr
305   310   315   320

Gly Phe Ser His Leu Gly Tyr Ala Lys Gly Ser Leu Pro Val Thr Glu
            325   330   335

Ala Leu Ala Asp Glu Ile
            340

<210> 3
<211> 293
<212> PRT
<213> Streptomyces nogalater ATCC 27451

<220>
<223> "translate of snogJ, function: dTDP-glucose synthase"

<400> 3

Val Lys Gly Ile Ile Leu Ala Gly Gly Thr Gly Ser Arg Leu His Pro
1   5   10   15

Thr Thr Leu Ala Val Ser Lys Gln Leu Leu Pro Val Gly Asp Lys Pro
      20   25   30

Met Ile Tyr Tyr Pro Leu Ser Val Leu Met Leu Ala Gly Val Thr Asp
     35   40   45

Ile Leu Ile Ile Ser Thr Pro His Glu Leu Pro Arg Met Arg Arg Leu
   50   55   60

Phe Gly Asp Gly Ala Gln Leu Gly Leu Arg Leu Ala Tyr Ala Glu Gln
65   70   75   80

Glu Lys Pro Arg Gly Ile Ala Glu Ala Phe Leu Ile Gly Ala Asp His
       85   90   95

Val Gly Ser Asp Ala Val Ala Leu Ala Leu Gly Asp Asn Ile Phe His
      100   105   110

Gly Ser Ser Phe Gln Gly Val Leu Arg Lys Glu Ala Glu Glu Leu Asp
     115   120   125

Gly Cys Val Leu Phe Gly Tyr Pro Val Lys Asp Pro Gln Arg Tyr Gly
   130   135   140

Val Gly Glu Ala Asn Ala Ser Gly Arg Leu Val Ser Ile Glu Glu Lys
145   150   155   160

Pro Val Arg Pro Arg Ser Asn Arg Ala Ile Thr Gly Leu Tyr Phe Tyr
      165   170   175

Asp Asn Glu Val Val Asp Ile Ala Arg Arg Leu Arg Pro Ser Ala Arg
     180   185   190

Gly Glu Leu Glu Ile Thr Asp Ile Asn Arg Thr Tyr Met Glu Arg Gly
    195   200   205

Arg Ala Arg Leu Val Asp Leu Gly Arg Gly Phe Ala Trp Leu Asp Thr
 210   215   220

Gly Thr Pro Glu Ser Leu Leu Gln Ala Ser Gln Tyr Val Ser Ala Leu
225   230   235   240

Glu Glu Arg Gln Gly Ile Arg Ile Ala Cys Ile Glu Glu Val Ala Leu

Arg Met Gly Phe Ile Asn Ala Gln Ala Cys Tyr Glu Leu Gly Ala Arg
            260   265   270

Leu Ser Gly Ser Gly Tyr Gly Gln Tyr Val Met Ala Ile Ala Glu Glu
            275   280   285

Cys Thr Gly Arg Val
    290

<210> 4
<211> 238
<212> PRT
<213> Streptomyces nogalater ATCC 27451

<220>
<223> "translate of snogA, function: aminomethyl transferase"

<400> 4

Val Tyr Gly Arg Glu Leu Ala Asp Val Tyr Glu Met Val Tyr Arg Ser
1   5   10   15

Arg Gly Lys Ser Trp Ala Asp Glu Ala Glu Arg Val Thr Ala Glu Ile
            20   25   30

Arg Ser Arg Arg Pro Gly Ala Arg Ser Leu Leu Asp Val Ala Cys Gly
        35   40   45

Thr Gly Ala His Leu Glu Ala Phe Arg Gly Leu Phe Ala His Thr Glu
    50   55   60

Gly Leu Glu Leu Ser Asp Glu Met Arg Ala Leu Ala Glu Arg Arg Leu
65   70   75   80

Pro Gly Val Pro Val Arg Pro Gly Asp Met Arg Asp Phe Ala Leu Ser
            85   90   95

Gly Arg Phe Asp Ala Val Val Cys Leu Phe Cys Ser Ile Gly Tyr Leu
            100   105   110

Glu Thr Val Ala Asp Met Arg Ala Ala Val Arg Thr Met Ala Ala His
            115   120   125

Leu Val Pro Gly Gly Val Leu Val Val Glu Pro Trp Trp Phe Pro Glu
            130   135   140

Arg Phe Leu Glu Gly Tyr Val Ala Gly Asp Leu Ala Arg Gly Glu Gly
145   150   155   160

Arg Thr Val Ala Arg Val Ser His Ser Thr Arg Gln Gly Arg Arg Thr
            165   170   175

Arg Met Glu Val Arg Phe Leu Val Gly Glu Ala Thr Gly Ile Arg Glu
        180   185   190

Phe Thr Glu Ile Asp Leu Leu Thr Leu Phe Thr Arg Glu Glu Tyr Leu
        195   200   205

Ala Ala Phe Glu Asp Ala Gly Cys Pro Ala Glu Phe Leu Asp Asp Gly
    210   215   220

Leu Thr Gly Arg Gly Leu Phe Val Gly Val Arg Gly Ala Gly
225   230   235

<210> 5
<211> 324
<212> PRT
<213> Streptomyces nogalater ATCC 27451

<220>
<223> "translate of snoaM, function: polyketide cyclase"

<400> 5

Met Thr Ala Ala Trp Gly Ala Pro Leu Tyr Pro Pro Trp Ile Pro Ala
1   5   10   15

Arg Pro Gly Arg Arg Arg Cys Gly Ala Gly Arg Arg Val Arg Cys Pro
        20   25   30

Pro Val Glu Pro Ala Ser Arg Pro Arg Gln Glu Gly Arg Val Ser Val
        35   40   45

Val Pro Ala Leu Arg Gln Pro Ser Pro Ser Thr Asn Pro Glu Val Arg
    50   55   60

Val Arg Leu Ile Asp Leu Ser Ser Pro Val Asp Ser Ser Gln Tyr Glu
65   70   75   80

Pro Asp Pro Val Val His Asp Val Leu Thr Pro Arg Gln Gly Ala Glu
            85   90   95

His Met Cys Ala Glu Met Arg Glu His Phe Gly Val Glu Phe Ser Pro
     100   105   110

Asp Glu Leu Pro Asp Gly Glu Phe Leu Ser Leu Asp Arg Ile Thr Leu
     115   120   125

Thr Thr His Thr Gly Thr His Val Asp Ala Pro Ser His Tyr Gly Ser
    130   135   140

Arg Ala Leu Tyr Gly Asp Gly Val Pro Arg His Ile Asp Gln Met Pro
145   150   155   160

Leu Glu Trp Phe Phe Gly Arg Gly Val Val Leu Asp Leu Thr Asp Ala
      165   170   175

Pro Thr Gly Thr Val Ser Ala Ala Arg Leu Glu Lys Glu Leu Ala Arg
     180   185   190

Thr Gly Cys Ala Leu Arg Pro Gly Asp Ile Val Leu Leu His Thr Gly
     195   200   205

Ala Gln Arg His Ala Gly Thr Pro Arg Tyr Phe Thr Asp Phe Ala Gly
    210   215   220

Leu Asp Gly Pro Ala Val Arg Met Leu Leu Asp His Gly Val Arg Val
225   230   235   240

Ile Gly Thr Asp Ala Phe Ser Leu Asp Ala Pro Phe Gly His Ile Ile
      245   250   255

Asp Arg Tyr Arg Ala Thr Gly Asp Arg Ser Val Leu Trp Pro Ala His
     260   265   270

Val Val Gly Arg Glu Arg Glu Tyr Cys Gln Ile Glu Arg Leu Ala Asn
     275   280   285

Leu Asp Arg Leu Pro Val Ser Phe Gly Phe Arg Val Cys Cys Phe Pro
    290   295   300

Val Lys Val Ala Gly Ala Gly Ala Gly Trp Thr Arg Ala Val Ala Leu
305   310   315   320

Val Asp Glu Asp

<210> 6
<211> 408
<212> PRT

<213> Streptomyces nogalater ATCC 27451

<220>
<223> "translate of snogN, function: unknown"

<400> 6

Met Val Met Lys Leu Thr Asp Ser Glu Leu Gly Arg Ala Leu Leu Ser
1   5   10   15

Leu Arg Gly Tyr Gln Trp Leu Arg Gly Ile His His Asp Pro Tyr Ala
            20   25   30

Leu Leu Leu Arg Ala Glu Ser Asp Asp Pro Ala Gln Leu Gly Arg Leu
        35   40   45

Leu Arg Glu Arg Gly Arg Leu His Arg Ser Asp Thr Gly Thr Trp Val
    50   55   60

Thr Ala Asp His Ala Thr Ala Ser Arg Leu Leu Ala Asp Pro Arg Phe
65   70   75   80

Val Leu Arg Arg Pro Pro Ala Gly Pro Ala Thr Gly Thr Gly Asp Val
            85   90   95

Met Pro Trp Glu Glu Ala Thr Leu Ser Asp Leu Leu Pro Leu Asp Glu
            100   105   110

Ala Arg Leu Thr Thr Asp Arg Ala Arg Cys Arg Arg Leu Gly Ala Thr
        115   120   125

Ala Ala Arg Ile Ala Ala Asp Gly Pro Val Ala Thr Arg Leu Ala Asp
    130   135   140

Leu Ala Gly Ala Arg Ala Glu Gln Val Arg Ser Thr Gly His Phe Asp
145   150   155   160

Leu Arg Ala Asp Tyr Ala Leu Pro Tyr Ala Val Glu Pro Ala Cys Ala
            165   170   175

Leu Leu Gly Leu Pro Ala Gly Gln Cys Ser Leu Phe Gly Ala Phe Ser
            180   185   190

Pro Ala Val Leu Leu Asp Ala Thr Val Val Pro Pro Arg Leu Pro Glu
            195   200   205

Ala Arg Ala Leu Ile Ala Ser Thr Ala Glu Leu Thr Ala Leu Trp Pro

Arg Leu Ala Pro Ser Leu Ser Lys Thr Val Pro Glu Asp Glu Ala Pro
225   230   235   240

Asp Leu Phe Leu Leu Thr Ala Val Leu Leu Val Pro Ala Val Val His
      245   250   255

Leu Val Cys Glu Ala Val Ala Ala Leu Ser His Asp Pro Gly Gln Ala
      260   265   270

Gly Leu Leu Arg Asp Asp Pro Val Leu Ala Ala Pro Ala Val Glu Glu
      275   280   285

Thr Leu Arg His Ala Pro Pro Ala Arg Leu Phe Thr Leu His Ala Thr
  290   295   300

Gly Pro Glu Arg Val Ala Asp Val Asp Leu Pro Ala Gly Ala Glu Val
305   310   315   320

Ala Val Val Val Ala Ala Ala His Arg Asp Pro Ser Trp Cys Pro Asp
      325   330   335

Pro Asp Arg Phe Asp Leu Thr Arg Asn Glu Arg His Leu Ala Leu Pro
      340   345   350

Pro Asp Leu Pro Leu Gly Ala Leu Ala Pro Leu Leu Arg Val Cys Ala
      355   360   365

Thr Ala Ala Val Ala Ala Leu Ala Ala Gly Leu Leu Pro Leu Arg Ala
  370   375   380

Val Gly Pro Pro Val Arg Arg Leu Arg Ala Pro Val Thr Arg Ser Val
385   390   395   400

Leu Arg Phe Pro Val Ala Pro Cys
      405

<210> 7
<211> 422
<212> PRT
<213> Streptomyces nogalater ATCC 27451

<220>
<223> "translate of snoaG, function: hydroxylase"

<400> 7

Met Asp Asn Arg Glu Thr Val Arg Pro Val Ser Val Cys Arg Val Cys
1   5   10   15

Gly Gly Asn Asp Trp Gln Asp Val Val Asp Phe Gly Asp Val Pro Leu
        20   25   30

Ala Asn Gly Phe Leu Ser Pro Ala Asp Ser Tyr Glu Asn Glu Arg Arg
        35   40   45

Tyr Pro Leu Gly Val Leu Ser Cys Arg Ala Cys Arg Leu Met Ser Leu
        50   55   60

Thr His Val Val Asp Pro Glu Val Leu Tyr Arg Asp Tyr Ala Tyr Thr
65   70   75   80

Thr Pro Asp Ser Glu Met Ile Thr Gln His Met Arg His Ile Thr Ala
            85   90   95

Leu Cys Arg Thr Arg Phe Glu Leu Pro Pro Asp Ser Leu Val Val Glu
        100   105   110

Leu Gly Ser Asn Thr Gly Arg Gln Leu Met Ala Phe Arg Glu Ala Gly
        115   120   125

Met Arg Thr Leu Gly Val Asp Pro Ala Arg Asn Leu Thr Asp Val Ala
        130   135   140

Arg Arg Asn Gly Ile Glu Thr Phe Pro Asp Phe Phe Ser His Asp Val
145   150   155   160

Ala Arg Thr Ile Arg Arg Asp His Gly Gln Ala Arg Leu Val Leu Gly
        165   170   175

Arg His Val Phe Ala His Ile Asp Asp Val Ser Asp Ile Ala Ala Gly
        180   185   190

Val Arg Glu Leu Leu Ser Pro Asp Gly Val Phe Ala Ile Glu Val Pro
        195   200   205

Tyr Val Leu Asp Leu Leu Glu Lys Val Ala Phe Asp Thr Ile Tyr His
210   215   220

Glu His Leu Ser Tyr Phe Thr Met Arg Ser Phe Val Thr Leu Phe Ala
225   230   235   240

Arg His Gly Leu Arg Val Leu Asp Val Glu Arg Phe Gly Val His Gly

Gly Ser Val Leu Val Phe Val Gly His Glu Asp Gly Pro Trp Pro Glu
        260   265   270

Arg Pro Ser Val Pro Glu Leu Leu Arg Val Glu Arg Gln Arg Gly Leu
        275   280   285

Tyr Asp Asp Ala Thr Tyr Arg Thr Phe Ala Gln Arg Ile Glu Arg Val
        290   295   300

Arg Thr Glu Leu Pro Glu Leu Leu Arg Ser Leu Val Ala Gln Gly Lys
305   310   315   320

Arg Ile Val Gly Tyr Gly Ala Pro Ala Lys Gly Asn Thr Ile Leu Thr
        325   330   335

Val Cys Gly Leu Gly Leu Lys Glu Leu Glu Tyr Cys Thr Asp Thr Thr
        340   345   350

Glu Leu Lys Gln Gly Arg Val Leu Pro Gly Thr His Ile Pro Val His
        355   360   365

Ala Pro Glu His Ala Lys Glu His Ile Pro Asp Tyr Tyr Leu Leu Leu
        370   375   380

Ala Trp Asn Tyr Ala Thr Glu Ile Leu Asp Lys Glu Thr Ala Phe Arg
385   390   395   400

Asp Asn Gly Gly Arg Phe Ile Val Pro Ile Pro Arg Pro Ser Ile Leu
        405   410   415

Thr Ser Pro Ser Gly Ser
        420

<210> 8
<211> 291
<212> PRT
<213> Streptomyces nogalater ATCC 27451

<220>
<223> "translate of snogC, function: dTDP-4-dehydrorhamnose reductase"

<400> 8

Met Leu Ala Arg His Leu Thr Ala Ala Leu Ala Glu Thr Gly Arg Ser
1   5   10   15

Arg Pro Ala Ala Glu Ala Val Val Leu Gly Arg Arg Ala Leu Asp Ile
    20   25   30

Thr Asp Gly Arg Ala Val Asp Ala Ala Phe Ala Ala His Arg Pro Arg
    35   40   45

Val Val Val Asn Cys Ala Ala Phe Thr Asp Val Asp Gly Ala Glu Ser
   50   55   60

Arg Trp Ala Glu Ala Met Arg Val Asn Gly Gly Gly Pro Arg Leu Leu
65   70   75   80

Ala Arg Arg Cys Ala Arg His Gly Val Arg Leu Ile His Val Ser Thr
        85   90   95

Asp Tyr Val Phe Pro Gly Asp Thr Arg Ser Pro Tyr Gly Glu Ser Asp
     100   105   110

Ala Pro Gly Pro Arg Thr Val Tyr Gly Arg Ser Lys Leu Ala Gly Glu
    115   120   125

Arg Ala Val Leu Ser Leu Leu Pro Asp Thr Gly Thr Val Val Arg Thr
   130   135   140

Ala Trp Leu Tyr Gly Gly Gln Gly Arg Ser Phe Val Arg Thr Met Leu
145   150   155   160

Glu Arg Ala Pro Asp Asp Gly His Val Asp Val Val Asn Asp Gln Trp
    165   170   175

Gly Gln Pro Thr Trp Ala Gly Asp Val Ala Arg Leu Leu Val Thr Leu
    180   185   190

Ala Arg Thr Pro Pro Asp Arg Ala Arg Gly Ile Phe His Ala Thr Asn
    195   200   205

Ala Gly Ala Ala Thr Trp Tyr Glu Leu Ala Arg Glu Val Phe Arg Leu
    210   215   220

Ala Gly Ala Asp Pro Glu Arg Val Arg Pro Val Ala Thr Ala Asp Arg
225   230   235   240

Pro Gly Pro Ala Pro Arg Pro Ala Cys Thr Val Leu Gly His Asp Arg
     245   250   255

Trp Arg Leu Val Gly Val Ala Pro Pro Arg Asp Trp Arg Ala Ala Leu

260   265   270

Arg Glu Ala Met Arg Gln Leu Leu Pro Gly Gly Arg Leu Arg Asn Leu
        275   280   285

Thr Gly Thr
    290

<210> 9
<211> 350
<212> PRT
<213> Streptomyces nogalater ATCC 27451

<220>
<223> "translate of snogK, function: dTDP-glucose-4,6-dehydratase"

<400> 9

Met Ala Ser His Thr Ser Ala Thr Thr Asp Val Asn Ile Leu Val Thr
1   5   10   15

Gly Ala Val Gly Phe Ile Gly Ser Ala Tyr Val Arg Met Leu Leu Glu
        20   25   30

Asn Arg Ala Pro Gly Ala Gly Ala Pro Ala Val Arg Val Thr Val Leu
        35   40   45

Asp Lys Leu Thr Tyr Ala Gly Asn Leu Thr Asn Leu Asp Ala Val Arg
    50   55   60

Gly Asp Arg Leu Arg Phe Val Arg Gly Asp Ile Leu Asp Ala Glu Leu
65   70   75   80

Val Asp Glu Leu Met Ala His Ser Asp Gln Val Val His Phe Ala Ala
        85   90   95

Glu Ser His Val Asp Arg Ser Ile Arg Ala Ala Asp Asp Phe Val Leu
        100   105   110

Thr Asn Val Val Gly Thr Gln Arg Leu Leu Asp Ala Ala Leu Arg His
        115   120   125

Gly Val Glu Pro Phe Val Leu Val Ser Thr Asp Glu Val Tyr Gly Ser
    130   135   140

Ile Ala Ser Gly Ser Trp Pro Glu Glu His Pro Leu Ser Pro Asn Ser
145   150   155   160

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Pro Tyr Ala Ala Ser Lys Ala Ser Ala Asp Leu Met Ala Phe Ala Cys
            165   170   175

His Arg Thr His Gly Leu Asp Val Arg Val Thr Arg Cys Ser Asn Asn
        180   185   190

Tyr Gly Pro Arg Gln His Pro Glu Lys Leu Ile Pro Arg Phe Val Thr
        195   200   205

Asn Leu Leu Asp Gly Leu Pro Val Pro Leu Tyr Gly Asp Gly Arg Asn
  210   215   220

Val Arg Glu Trp Leu His Val Glu Asp His Cys Arg Gly Val Asp Leu
225   230   235   240

Val Arg Thr Ala Gly Arg Pro Gly Gly Val Tyr His Ile Gly Gly Gly
        245   250   255

Arg Glu Leu Ser Asn Arg Glu Leu Val Gly Met Leu Leu Glu Leu Cys
        260   265   270

Gly Ala Asp Trp Ser Ser Val Arg His Val Pro Asp Arg Lys Gly His
        275   280   285

Asp Leu Arg Tyr Ser Leu Asp Trp Gly Arg Ala Arg Glu Glu Leu Gly
  290   295   300

Tyr Arg Pro Ala Arg Glu Phe Ser Ser Gly Leu Arg Ser Thr Val Gln
305   310   315   320

Trp Tyr Arg Glu Asn Arg Ser Trp Trp Glu Pro Leu Lys Arg Gly Val
        325   330   335

Thr Ala Pro Gly Gly Thr Ser Thr Val Val Pro Gly Val Arg
        340   345   350

<210> 10
<211> 134
<212> PRT
<213> Streptomyces nogalater ATCC 27451

<220>
<223> "translate of snoaL, function: NAME cyclase"

<400> 10

Met Val Ser Ala Phe Asn Thr Gly Arg Thr Asp Asp Val Asp Glu Tyr
1   5   10   15

Ile His Pro Asp Tyr Leu Asn Pro Ala Thr Leu Glu His Gly Ile His
         20   25   30

Thr Gly Pro Lys Ala Phe Ala Gln Leu Val Gly Trp Val Arg Ala Thr
         35   40   45

Phe Ser Glu Glu Ala Arg Leu Glu Glu Val Arg Ile Glu Glu Arg Gly
        50   55   60

Pro Trp Val Lys Ala Tyr Leu Val Leu Tyr Gly Arg His Val Gly Arg
65   70   75   80

Leu Val Gly Met Pro Pro Thr Asp Arg Arg Phe Ser Gly Glu Gln Val
              85   90   95

His Leu Met Arg Ile Val Asp Gly Lys Ile Arg Asp His Arg Asp Trp
         100   105   110

Pro Asp Phe Gln Gly Thr Leu Arg Gln Leu Gly Asp Pro Trp Pro Asp
         115   120   125

Asp Glu Gly Trp Arg Pro
   130

<210> 11
<211> 235
<212> PRT
<213> Streptomyces nogalater ATCC 27451

<220>
<223> "translate of snoK, function: unknown"

<400> 11

Met Pro Asp Pro Gly Gly Pro Thr Thr Ala Glu Asn Leu Ser Lys Glu
1   5   10   15

Ala Val Arg Phe Tyr Arg Glu Gln Gly Tyr Val His Ile Pro Arg Val
         20   25   30

Leu Ser Glu Thr Glu Val Thr Ala Phe Arg Ala Ala Cys Glu Glu Val
         35   40   45

Leu Glu Lys Glu Gly Arg Glu Ile Ser Gly Ile Ala Leu Arg Leu Ala

Gly Ala Pro Leu Arg Val Tyr Ser Ser Asp Ile Leu Val Lys Glu Pro
65   70   75   80

Lys Arg Thr Leu Pro Thr Leu Val His Asp Asp Glu Thr Gly Leu Pro
          85   90   95

Leu Asn Glu Leu Ser Ala Thr Leu Thr Ala Trp Ile Ala Leu Thr Asp
          100   105   110

Val Pro Val Glu Arg Gly Cys Met Ser Tyr Val Pro Gly Ser His Leu
          115   120   125

Arg Ala Arg Glu Asp Arg Gln Glu His Met Thr Ser Phe Ala Glu Phe
          130   135   140

Arg Asp Leu Ala Asp Val Trp Pro Asp Tyr Pro Trp Gln Pro Arg Val
145   150   155   160

Ala Val Pro Val Arg Ala Gly Asp Val Val Phe His His Cys Arg Thr
          165   170   175

Val His Met Ala Glu Ala Asn Thr Ser Asp Ser Val Arg Met Ala His
          180   185   190

Gly Val Val Tyr Met Asp Ala Asp Ala Thr Tyr Arg Pro Gly Val Gln
          195   200   205

Asp Gly His Leu Ser Arg Leu Ser Pro Gly Asp Pro Leu Glu Gly Glu
          210   215   220

Leu Phe Pro Leu Val Thr Ala Gly Thr Arg Gln
225   230   235

<210> 12
<211> 390
<212> PRT
<213> Streptomyces nogalater ATCC 27451

<220>
<223> "translate of snogD, function: glycosyl transferase"

<400> 12

Met Arg Val Pro Gly Ser Cys Arg Thr Gly Gly Ile Met Arg Ala Leu
1   5   10   15

Phe Ile Thr Ser Pro Gly Leu Ser His Ile Leu Pro Thr Val Pro Leu
     20   25   30

Ala Gln Ala Leu Arg Ala Leu Gly His Glu Val Arg Tyr Ala Thr Gly
     35   40   45

Gly Asp Ile Arg Ala Val Ala Glu Ala Gly Leu Cys Ala Val Asp Val
    50   55   60

Ser Pro Gly Val Asn Tyr Ala Lys Leu Phe Val Pro Asp Asp Thr Asp
65   70   75   80

Val Thr Asp Pro Met His Ser Glu Gly Leu Gly Glu Gly Phe Phe Ala
      85   90   95

Glu Met Phe Ala Arg Val Ser Ala Val Ala Val Asp Gly Ala Leu Arg
     100   105   110

Thr Ala Arg Ser Trp Arg Pro Asp Leu Val Val His Thr Pro Thr Gln
   115   120   125

Gly Ala Gly Pro Leu Thr Ala Ala Ala Leu Gln Leu Pro Cys Val Glu
   130   135   140

Leu Pro Leu Gly Pro Ala Asp Ser Glu Pro Gly Leu Gly Ala Leu Ile
145   150   155   160

Arg Arg Ala Met Ser Lys Asp Tyr Glu Arg His Gly Val Thr Gly Glu
   165   170   175

Pro Thr Gly Ser Val Arg Leu Thr Thr Thr Pro Pro Ser Val Glu Ala
   180   185   190

Leu Leu Pro Glu Asp Arg Arg Ser Pro Gly Ala Trp Pro Met Arg Tyr
   195   200   205

Val Pro Tyr Asn Gly Gly Ala Val Leu Pro Asp Trp Leu Pro Pro Ala
 210   215   220

Ala Gly Arg Arg Arg Ile Ala Val Thr Leu Gly Ser Ile Asp Ala Leu
225   230   235   240

Ser Gly Gly Ile Ala Lys Leu Ala Pro Leu Phe Ser Glu Val Ala Asp
   245   250   255

Val Asp Ala Glu Phe Val Leu Thr Leu Gly Gly Gly Asp Leu Ala Leu

Leu Gly Glu Leu Pro Ala Asn Val Pro Val Val Glu Trp Ile Pro Leu
　　275　　　　280　　　　285

Gly Ala Leu Leu Glu Thr Cys Asp Ala Ile Ile His His Gly Gly Ser
　290　　　　295　　　　300

Gly Thr Leu Leu Thr Ala Leu Ala Ala Gly Val Pro Gln Cys Val Ile
305　　　　310　　　　315　　　　320

Pro His Gly Ser Tyr Gln Asp Thr Asn Arg Asp Val Leu Thr Gly Leu
　　　325　　　　330　　　　335

Gly Ile Gly Phe Asp Ala Glu Ala Gly Ser Leu Gly Ala Glu Gln Cys
　　340　　　　345　　　　350

Arg Arg Leu Leu Asp Asp Ala Gly Leu Arg Glu Ala Ala Leu Arg Val
　　355　　　　360　　　　365

Arg Gln Glu Met Ser Glu Met Pro Pro Pro Ala Glu Thr Ala Ala Lys
　370　　　　375　　　　380

Leu Val Ala Leu Ala Gly
385　　　　390

<210> 13
<211> 275
<212> PRT
<213> Streptomyces nogalater ATCC 27451

<220>
<223> "translate of snoW, function: unknown"

<400> 13

Met Thr Val Leu Val Thr Gly Ala Thr Gly Asn Val Gly Arg His Val
1　　　　5　　　　10　　　　15

Val Thr Gly Leu Leu Ala Ala Gly Arg Arg Val Arg Ala Leu Thr Arg
　　20　　　　25　　　　30

Thr Pro Asp Arg Ser Gly Leu Pro Gly Gly Ala Glu Ile Thr Gly Gly
　　35　　　　40　　　　45

Asp Leu Thr Arg Pro Glu Thr Tyr Glu Arg Met Leu Asp Gly Val Glu
　50　　　　55　　　　60

Ala Val Tyr Leu Phe Pro Val Pro Glu Thr Ala Ala Ala Phe Ala Gly
65   70   75   80

Ala Ala Arg Arg Ala Gly Val Arg Arg Ile Val Val Leu Ser Ser Asp
        85   90   95

Ser Val Thr Asp Gly Thr Asp Thr Gly Gly His Arg Arg Val Glu Leu
        100   105   110

Ala Val Glu Asp Thr Gly Leu Glu Trp Thr His Val Arg Pro Gly Glu
        115   120   125

Phe Ala Leu Asn Lys Val Thr Leu Trp Ala Pro Ser Ile Arg Ala Glu
        130   135   140

Gly Val Val Arg Ser Ala Tyr Pro Asp Ala Arg Val Ala Pro Val His
145   150   155   160

Glu Ala Asp Val Ala Ala Val Ala Val Thr Ala Leu Leu Lys Glu Gly
        165   170   175

His Ala Gly Arg Ala Tyr Ser Val Thr Gly Pro Gln Ala Leu Thr Gln
        180   185   190

Arg Glu Gln Val Arg Ala Val Gly Glu Gly Leu Gly Arg Ser Leu Ala
        195   200   205

Phe Val Glu Val Thr Pro Gly Gln Ala Arg Ala Asp Leu Thr Ala Gln
        210   215   220

Gly Leu Pro Ala Pro Ile Ala Asp Tyr Val Leu Ala Phe Gln Ala Gly
225   230   235   240

Trp Thr Glu Arg Pro Ala Pro Ala Arg Pro Thr Val Arg Glu Val Thr
        245   250   255

Gly Arg Pro Ala Arg Thr Leu Ala Gln Trp Ala Ala Asp His Arg Ala
        260   265   270

Asp Phe Arg
    275

<210> 14
<211> 424
<212> PRT
<213> Streptomyces nogalater ATCC 27451

<220>
<223> "translate of snogE, function: glycosyl transferase"

<400> 14

Val Arg Val Leu Leu Thr Ser Phe Ala Met Asp Ala His Phe Cys Thr
1   5   10   15

Ala Val Pro Leu Ala Trp Ala Leu Arg Ser Ala Gly His Glu Val Arg
        20   25   30

Val Ala Gly Gln Pro Ala Leu Thr Ser Thr Ile Thr Gly Ala Gly Leu
        35   40   45

Thr Ala Val Pro Val Gly Arg Asp His Thr His Gly Ser Leu Leu Gly
    50   55   60

Arg Val Gly Ser Asp Ile Leu Ala Leu His Asp Glu Ala Asp Tyr Leu
65   70   75   80

Glu Ala Arg His Asp Ala Leu Gly Phe Glu Phe Leu Lys Gly His Asn
            85   90   95

Thr Val Met Ser Ala Leu Phe Tyr Ser Gln Ile Asn Asn Asp Ser Met
            100   105   110

Val Asp Asp Leu Val Asp Phe Ala Arg His Trp Arg Pro Asp Leu Val
        115   120   125

Val Trp Glu Pro Phe Thr Phe Ala Gly Ala Val Ala Ala Arg Ala Ser
    130   135   140

Gly Ala Ala His Ala Arg Leu Leu Ser Phe Pro Asp Leu Phe Leu Ser
145   150   155   160

Thr Arg Arg Leu Phe Leu Glu Arg Met Ala Arg Gln Glu Pro Glu His
            165   170   175

His Asp Asp Thr Leu Ala Glu Trp Leu Asp Trp Thr Leu Gly Arg His
            180   185   190

Gly His Ser Phe Asp Glu Glu Ile Val Thr Gly Gln Trp Ser Ile Asp
        195   200   205

Gln Thr Pro Ala Pro Val Arg Leu Asp Ala Gly Gly Pro Thr Val Pro
    210   215   220

Met Arg Tyr Val Pro Tyr Ser Gly Leu Val Pro Thr Val Val Pro Asp
225   230   235   240

Trp Leu Arg Arg Pro Pro Glu Arg Pro Arg Val Leu Val Thr Leu Gly
     245   250   255

Ile Thr Ser Arg Arg Val Lys Ser Phe Leu Ala Val Ser Val Asp Asp
     260   265   270

Leu Phe Glu Ala Val Ala Gly Leu Gly Val Glu Val Val Ala Thr Leu
     275   280   285

Asp Ala Asp Gln Arg Glu Leu Leu Gly Arg Val Pro Asp His Phe Arg
   290   295   300

Ile Val Glu His Val Pro Leu Asp Ala Val Leu Pro Thr Cys Ser Ala
305   310   315   320

Ile Val His His Gly Gly Ala Gly Thr Trp Ser Thr Ala Ala Val Tyr
     325   330   335

Gly Val Pro Gln Val Ser Leu Gly Ser Met Trp Asp His Phe Tyr Arg
     340   345   350

Ala Arg Arg Leu Glu Glu Leu Gly Ala Gly Leu Arg Leu Pro Ser Gly
     355   360   365

Glu Leu Thr Ala Glu Gly Leu Arg Thr Arg Leu Glu Arg Val Leu Gly
   370   375   380

Glu Pro Ser Phe Gly Thr Ala Ala Gln Ala Leu Ser Asp Thr Ile Ala
385   390   395   400

Ala Glu Pro Ser Pro Ser Glu Val Val Pro Val Leu Glu Glu Leu Thr
     405   410   415

Gly Arg His Arg Pro Gly Thr Arg
     420

<210> 15
<211> 139
<212> PRT
<213> Streptomyces nogalater ATCC 27451

<220>
<223> "translate of snoL, function: unknown"

<400> 15

Met Ser Thr Thr Ala Asn Lys Glu Arg Cys Leu Glu Met Val Ala Ala
1   5   10   15

Trp Asn Arg Trp Asp Val Ser Gly Val Val Ala His Trp Ala Pro Asp
            20   25   30

Val Val His Tyr Asp Asp Glu Asp Lys Pro Val Ser Ala Glu Glu Val
        35   40   45

Val Arg Arg Met Asn Ser Ala Val Glu Ala Phe Pro Asp Leu Arg Leu
    50   55   60

Asp Val Arg Ser Ile Val Gly Glu Gly Asp Arg Val Met Leu Arg Ile
65   70   75   80

Thr Cys Ser Ala Thr His Gln Gly Val Phe Met Gly Ile Ala Pro Thr
            85   90   95

Gly Arg Lys Val Arg Trp Thr Tyr Leu Glu Glu Leu Arg Phe Ser Glu
        100   105   110

Ala Gly Lys Val Val Glu His Trp Asp Val Phe Asn Phe Ser Pro Leu
        115   120   125

Phe Arg Asp Leu Gly Val Val Pro Asp Gly Leu
    130   135

<210> 16
<211> 155
<212> PRT
<213> Streptomyces nogalater ATCC 27451

<220>
<223> "translate of snoO, function: homologous to mtmX of
      mithramycin cluster"

<400> 16

Met Ser Val Arg Thr Asp Gln Thr Ala Ala Pro Glu Asp Arg Ala Ala
1   5   10   15

Ala Thr Asp Pro Gly Phe Gly His Leu Tyr Ala Gln Val Gln Gln Phe
            20   25   30

Tyr Ala Arg Gln Met Gln Leu Leu Asp Ser Gly Ala Ala Glu Glu Trp
   35   40   45

Ala Ala Thr Phe Thr Glu Asp Gly Thr Phe Ala Arg Pro Ser Ser Pro
  50   55   60

Glu Pro Ala Arg Gly His Ala Glu Leu Ala Ala Gly Ala Arg Ala Ala
65   70   75   80

Ala Glu Arg Leu Ala Ala Glu Gly Leu Ser His Arg His Val Ile Gly
      85   90   95

Met Thr Ala Val Arg Arg Glu Pro Asp Gly Ser Val Phe Val Arg Ser
    100   105   110

Tyr Ala Gln Val Phe Ala Thr Arg Arg Gly Glu Ala Pro Arg Leu His
   115   120   125

Leu Ile Cys Val Cys Glu Asp Val Leu Val Arg Glu Gly Pro Gly Leu
  130   135   140

Lys Val Arg Glu Arg Val Val Thr His Asp Ala
145   150   155

<210> 17
<211> 281
<212> PRT
<213> Streptomyces nogalater ATCC 27451

<220>
<223> "translate of snoaF, function: C-7 ketoreductase"

<400> 17

Val Arg Ala Met Thr Asp Ser Thr Gly Pro Arg Pro Val Pro Ala Met
1   5   10   15

Ser Pro Ala Pro Ser Pro Thr Pro Ser Pro Gly Pro Ala Pro Gly Ser
     20   25   30

Glu Pro Ala Pro Leu Ala Val Ile Val Thr Gly Gly Gly Ser Gly Ile
   35   40   45

Gly Arg Ala Thr Ala Arg Ala Phe Ala Ala Gln Gly Ala Lys Val Leu
  50   55   60

Val Val Gly Arg Thr Glu Asp Ala Leu Ala Gln Thr Ala Glu Gly Cys

Ala Asp Met Arg Val Leu Val Ala Asp Val Ala Ser Pro Asp Gly Pro
        85   90   95

Gln Ala Val Val Asn Ala Ala Leu Arg Glu Phe Gly Arg Ile Asp Val
        100   105   110

Leu Val Asn Asn Ala Ala Val Ala Gly Met Glu Thr Leu Gln Thr Val
       115   120   125

Asp Arg Asp Ala Val Ala Arg Gln Phe Gly Thr Asn Leu Thr Ala Pro
   130   135   140

Leu Phe Leu Val Gln Ser Ala Leu Gly Ala Leu Glu Lys Ser Arg Gly
145   150   155   160

Ile Val Val Asn Val Gly Thr Ala Ala Thr Leu Gly Leu Arg Ala Ala
      165   170   175

Pro Thr Gly Ala Leu Tyr Gly Ala Ser Lys Val Ala Leu Asp Tyr Leu
      180   185   190

Thr Arg Thr Trp Ala Val Glu Leu Ala Pro Arg Gly Ile Arg Val Val
   195   200   205

Gly Val Ala Pro Gly Val Ile Asp Thr Gly Ile Gly Val Arg Met Gly
   210   215   220

Met Thr Pro Glu Gly Tyr Arg Glu Phe Leu Thr Gly Met Gly Gly Arg
225   230   235   240

Val Pro Val Gly Arg Val Gly Arg Pro Glu Asp Val Ala Trp Trp Ile
      245   250   255

Val Gln Leu Ala Arg Pro Glu Ala Gly Tyr Ala Thr Gly Met Val Val
      260   265   270

Pro Val Asp Gly Gly Leu Ser Leu Val
      275   280

<210> 18
<211> 190
<212> PRT
<213> Streptomyces nogalater ATCC 27451

<220>

<223> "translate of snoN, function: unknown"

<400> 18

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Val Gln Glu Thr Glu Pro Gly Val Pro Ala Asp Leu Pro Ala Glu Ser
1               5                  10                 15

Asp Pro Ala Ala Leu Glu Arg Leu Ala Ala Arg Tyr Arg Arg Asp Gly
        20                25                30

Tyr Val His Val Pro Gly Val Leu Asp Ala Gly Glu Val Ala Glu Tyr
        35                40                45

Leu Ala Glu Ala Arg Arg Leu Leu Ala His Glu Glu Ser Val Arg Trp
     50               55                60

Gly Ser Gly Ala Gly Thr Val Met Asp Tyr Val Ala Asp Ala Gln Leu
65              70                75                80

Gly Ser Asp Thr Met Arg Arg Leu Ala Thr His Pro Arg Ile Ala Ala
         85                90                95

Leu Ala Glu Tyr Leu Ala Gly Ser Pro Leu Arg Leu Phe Lys Leu Glu
        100               105               110

Val Leu Leu Lys Glu Asn Lys Glu Lys Asp Ala Ser Val Pro Thr Ala
        115               120               125

Pro His His Asp Ala Phe Ala Phe Pro Phe Ser Thr Ala Gly Thr Ala
        130               135               140

Leu Thr Ala Trp Val Ala Leu Val Asp Val Pro Val Glu Arg Gly Cys
145             150               155               160

Met Thr Phe Val Pro Gly Ser His Leu Leu Pro Asp Pro Asp Thr Gly
         165               170               175

Asp Glu Pro Trp Ala Gly Ala Phe Thr Arg Pro Gly Glu Ile
        180               185               190
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